 By Ron Mancini

Predicting the ac performance of comparators

MY LAST COLUMN ("Adding hysteresis to comparators," *EDN*, May 3, 2001, pg 22) concluded that hysteresis decreases comparator accuracy and prevents multiple pulsing. Amplifying the input signal before applying it to the comparator increases the accuracy because the hysteresis-voltage range becomes smaller than the amplified input signal. There are ICs, such as the TLV2302, made for this function, and they contain an op amp and a comparator. Also, using the op amp as an amplifier/lowpass filter reduces the noise on the signal and can decrease the need for hysteresis.

Many comparators have an open-collector output stage for maximum flexibility. The open collector enables selection of the optimum collector resistor during the design stage. The external collector resistor, R_C, (often called a pullup resistor) connects between the positive supply rail and the comparator output. The input requirement of the driven circuit selects the collector resistor. When the input voltage forces the comparator's output to a high level, the open-collector transistor is off. The collector resistor supplies high-level output current per the equation $V_{OUT}=V_{CC}-I_LR_C$. (The power rails are V_{CC} and ground.) The collector resistor in series with the comparator-output capacitance forms an RC circuit that determines the output-voltage rise time. The driven circuit sets the rise-time requirement, and high-speed loads (TTL circuits) demand small rise times. The rise-time requirement is normally the more stringent requirement on the collector resistor.

The response time (or propagation-delay time) is the time delay between an input signal and the corresponding output signal. Semiconductor manufacturers specify it as the time delay from the leading edge of the input signal, which assumes negligible rise/fall time, to the 50% point of the comparator-output rise/fall time. The response time is a function of the input-voltage overdrive. "Overdrive" is the voltage in excess of that required to switch the output, and response time is not equal for rising and falling edges. **Table 1** tabulates the response times of a TLC339 comparator with V_{CC}=5V and R_C=5.1 kΩ.

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TABLE 1—TLC339 RESPONSE TIME

Overdrive (mV)	Low-to-high transition (μsec)	High-to-low transition (μsec)
2	4.5	3.6
5	2.5	2.1
10	1.7	1.3
20	1.2	0.85
40	1	0.55

When you apply a 500-nsec pulse with 2-mV overdrive to the comparator, you don't get an output response, because the comparator doesn't react before the input signal goes away. A 500-nsec pulse may yield a small blip in the output voltage that is too small to trigger the hysteresis. Always ensure that the overdrive/pulse-width combination is adequate to yield the expected response. Never depend on the comparator response time to filter noise pulses.

The comparator is a unique mixture of analog and digital technologies. The analog front end is high-gain; thus, noise easily corrupts it. The digital back end can switch as fast as a logic circuit, so it generates power-supply current spikes that the power-distribution impedance turns into voltage noise. You need to decouple all comparators at the power leads with a 0.01-μF ceramic capacitor in parallel with a 10-μF electrolytic capacitor. The stringent decoupling causes the digital noise to circulate through the decoupling capacitors back to the power rails with minimum generated noise. The 10-μF capacitor is good at low frequencies, and, when the 10-μF capacitor becomes useless at its self-resonant frequency, the 0.01-μF capacitor is still low-impedance.

Having the decoupling capacitor is the first rule in taming comparator ringing or oscillations. You should use a good ground plane to minimize power-distribution noise. Keep traces well separated to prevent noise coupling, and keep the input and output circuits well separated to prevent unwanted feedback. Finally, add the required hysteresis, and you have a working circuit. □

Ron Mancini is staff scientist at Texas Instruments. You can reach him at 1-352-569-9401, rmancini@ti.com.